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Vol. XVI, No. 14 May 1, 1937 GUY P. JONES
EDITOR

An Acute Epizootic of Septicemic and Pneumonic Plague in Ground Squirrels

By W. H. Kellogg, M.D., Chief, Division of Laboratories.

An epizootic of plague among the ground squirrels of Kern and Tulare counties in California presents certain aspects of interest to both epidemiologists and bacteriologists, particularly when considered in relation to another outbreak of rodent plague in an area four hundred miles away with no known infected areas in between. The record of rodent plague in California is as follows:

In August, 1908, a plague infected squirrel was found in Contra Costa County as a result of a survey prompted by the occurrence of two human cases in rural districts. Since then not a single year has elapsed without the finding of infected squirrels in one or more counties. The chart shows this record and it will be seen that the counties that have maintained the most constant record are the coastal counties of Alameda, Contra Costa, Monterey, San Benito, San Mateo, Santa Clara, and Santa Cruz. This may be in part due to more intensive search in these counties on account of their proximity to the large population centers of the Bay region, the original policy in squirrel eradication having been to produce a squirrel free zone around the Bay district. The total number of counties involved so far is nineteen, chart No. 2 showing the relation of the infected counties to the rest of the State.

A writer in 1914, as experienced as any at that time, ventured a prediction as to the future of plague in California. The basis of his article and the occasion for his optimism was the apparently complete suppression of plague as a result of the work of squirrel eradication that had been carried on jointly by the U. S. P. H. S. and the State Board of Health. This campaign included a survey for the presence of plague infection beginning in 1908, covering most of California and parts of adjacent States, and lasting until 1912, up to which time nine counties in California had been proven plague infected. Eradication measures were concentrated on the nine counties and during 1914 plague was found in four only, the number of foci being seven, the number of ranches invaded 21, and the number of infected squirrels found 69. At the time of writing, all these ranches had been thoroughly treated and hunted over from three to five times with the result that on only one ranch was a plague squirrel found after eradication measures were regarded as being completed. With this cheerful picture in mind and with complete forgetfulness of the history of plague, this author then says: "In view of the facts just set forth, it is believed that the statement can safely be made that all discoverable plague has been eradicated from the

State of California and that danger of its further spread has been removed."

What are the facts today, twenty years after the supposed complete eradication of the disease? Instead of nine known counties involved, the number is nineteen, and in the present year three new counties have been added in all three of which a virulent epizootic has been in progress. This is all in keeping with the known epidemiology of the disease. Plague is primarily a disease of rodents and characteristically it lies dormant in certain continuous foci of the disease from whence at intervals of decades or centuries it sallies forth in the form of human pandemics that are not only world wide but may be century long. In these endemic foci the infection resides in some wild rodent of hibernating habit. Historical foci are those of Arabia and Mesopotamia from whence the Black Death of the Middle Ages emerged, and in Thibet and in Uganda in Africa. In Yunnan in the interior of China is the focus from which is supposed to have originated the present pandemic which began with the appearance of plague in epidemic form in Hong Kong in 1894. Calcutta was the next port of call, since which time most of the world has been visited, and plague is still active in a dozen or more countries. San Francisco was reached in 1900. The deaths from plague in India as early as 1900 reached more than a million per year, while at the present time the deaths in that country are at the rate of two or three thousand per week. In California plague has not found the social conditions conducive to high mortality, but constant vigilance is necessary to prevent the occasional human epidemic which, although small in numbers as compared to India, nevertheless is high in damage represented by the cost of suppression and the commercial losses from the fears of the people.

As already observed, plague is primarily a disease of rodents and the rat is the particular rodent usually thought of as the source of human plague. It is true that rats are, with an exception to be noted later, the immediate origin of human outbreaks, but they are not the remote source. The rat is the disseminator of plague by reason of his traveling propensities and the beginning of a human pandemic probably is the infection of rats at some point of contact with the wild rodents of an endemic area. Human epidemics of bubonic plague result when plague has been introduced into the rat population, the infection spreading from rat to rat through the medium of the flea. The mechanism of the transfer is as follows: Fleas feeding on a rat with septicemic plague take up the bacilli with the blood. The plague bacilli do not infect the flea, but they multiply in the proventriculus resulting in obstruction so that on repeated efforts at feeding, blood is regurgitated onto the skin. Infection then takes place by entry of the organism through the bite puncture or other abrasion.

Plague in man assumes two clinical forms, the bubonic and the pneumonic. The former, characterized by involvement of the lymphatic glands forming buboes, is the commonest form and the one that principally prevailed during the epidemics of the Middle Ages called the Black Death. The pneumonic form, in which there is a pneumonia but usually no involvement of the lymphatic glands, is highly infectious from man to man direct without the mediation of rat or flea, because, the bacilli being in the sputum, transfer takes place by droplet infection. The case fatality rate of pneumonic plague is very high, almost one hundred per cent, and the duration of the illness very short, from a few hours to two or three days. Since the same bacillus is concerned in both types of infection, the reason for the occurrence of pneumonic epidemics is not clear, but there is some ground for believing that causes are both extrinsic and intrinsic. All pneumonias are favored by cold, damp weather and it is to be noted that the largest outbreaks of pneumonic plague, at least in modern times, have been in cold seasons. In India where the climate is warm, only two to five per cent of the cases have been pneumonic except in Kashmir at an elevation of five thousand feet where an epidemic of 1400 deaths occurred in very cold weather. Likewise the big pneumonic epidemics in Manchuria in 1911 occurred in winter weather. But there are manifestly other influences and these are of particular interest in relation to the epizootic of the present year in the new foci uncovered in the lower San Joaquin Valley and in the mountainous Modoc County district. I refer to the theory that a specific lung virulence is developed by the plague bacillus upon passage through rodents of squirrel and ground hog type. This is suggested by the fact that in our experience pneumonias among rats are uncommon, but among squirrels they are very common and the character persists in guinea pigs inoculated from these animals. Guinea pigs inoculated subcutaneously from rats and humans during the 1907 bubonic epidemic in San Francisco, according to my recollection, never showed lung involvement, whereas in Los Angeles during and following a human pneumonic outbreak when squirrels also were found infected the guinea pigs frequently showed a pneumonia. Further testimony is seen in the Oakland pneumonic plague epidemic which was started by a man who contracted an axillary bubo by squirrel contact and then developed a secondary pneumonia. The disastrous epidemic of pneumonic plague in Manchuria in 1910 and 1911 was not rat borne. It had its origin in trappers of tarbagans in the mountains. The tarbagan is the wild rodent that harbors plague endemically in that country.

There are two particularly disturbing aspects of the present season's ground squirrel epizootic. One of these is the demonstration that the ground squirrel infection not only is not decreasing after thirty years but is, on the contrary, increasing and expanding over a much wider territory. Not only in the Coast Range and the interior valleys, but now in the Sierras is it found. The establishment of a permanent endemic rodent focus is thus thoroughly demonstrated. In Asia such foci are apparently permanent. Perhaps in this country with our supposedly enlightened outlook on public health we may be able to root it out. The history of progress so far is not encouraging, however, and the more extensive the infected territory grows the more difficult and expensive will be the job.

The second important consideration relative to the appearance of plague in Kern, Tulare and Modoc counties this year is the evidence of renewed virulence and of increasing pulmonary tendency on the part of the prevailing strain of organism. The gross pathology of plague in ground squirrels is somewhat different from that in rats. In the latter animal there are five signs that may be encountered; rarely all at one time, frequently two, sometimes only one. These signs are subcutaneous injection, buboes, granular liver, large, dark spleen, and pleural effusion. In ground squirrels the subcutaneous injection which is of so much importance in rats is less noticeable. The liver, as in the rat, may show enlargement and a granular appearance. The spleen frequently resembles that organ in an inoculated guinea pig, being greatly enlarged and studded with yellowish specks of focal necrosis, thus differing notably from the rat in which animal the spleen rarely shows any specks but is smooth, dark, glistening, and has a dense swollen appearance. Buboes, usually solitary, are common in squirrels and the appearance of the bubo more ofter than in rats resembles the acutely necrotic and hemorrhagic bubo seen in man and in guinea pigs. The most characteristic difference of all between rats and squirrels is the finding of nodules and hemorrhages in the lungs of squirrels but not in rats. The squirrels received from Kern and Tulare counties this year have been remarkable in the number that have shown acute pulmonary plague, the appearance of the lungs being that of a lobular pneumonia with considerable edema exactly like the human disease. Furthermore, the virulence of the strain is manifested by cases which are so rapid in their progress that no well developed pneumonia or characteristic focal necroses of either spleen or liver had developed and no buboes, the animal dying of septicemia in a short time. This is a striking parallel to the gross pathology of human cases at the height of the epidemic of 1910 in Manchuria. There cases were seen where the lung involvement had not progressed beyond a stage of congestion, the victim dying of septicemia, the progress of the condition being so rapid that death occurred within twenty-four hours, no glandular involvement whatever being found.

The bacteriological identification of plague in rodents is beset with certain difficulties that do not disturb us in proving up a human case. It is not my intention here to describe in detail the identification of the plague bacillus, but merely to briefly mention certain outstanding features that are encountered. When stained smears from a human bubo show large numbers of cocco bacilli showing bipolar and gram negative staining or when a guinea pig inoculated with fluid aspirated from such a bubo dies with enlarged and punctate spleen and large numbers of bipolar bacilli are seen in smears, the case will be proven on further work to be one of plague. I know of no infection in man with the characteristic pathology of the plague bubo containing large numbers of bipolar organisms except plague. Such is not the case with rodents. Some of the Salmonellas may produce suspicious gross lesions and present suspicious appearing organisms in smears which cultures, however, soon rule out. I have seen colon bacilli in a spleen smear that had a bipolar appearance. Other Pasteurellas give considerable trouble sometimes. The bacillus Pseudo Tuberculosis Rodentium is occasionally encountered in squirrels and rats. This organism grows more rapidly and luxuriantly than plague and broth cultures grown at 22 degrees Centigrade are motile while plague is not. Plague grows very slowly in the beginning and after several days the cultures give a characteristic sticky or stringy effect when touched with a platinum needle. Tularemia is another infection that may cause confusion. The gross pathology can not be distinguished from plague. When guinea pigs are inoculated from a tularemic squirrel the same appearances are noted that are characteristic of plague, buboes, spleen, and all, except that the subcutaneous edema is lacking. Smears from the organs show at first glance no organisms at all. B. Tularense is not more than half a micron long and a field thick with them, to one not familiar with it, looks like a background of stained amorphous material or precipitated stain. Cultures tell the story as Tularense does not grow at all on plain agar, but gives a characteristic moist, greenish appearing growth on cystine blood agar. Mixed infections are sometimes found and these bring out all the resourcefulness of the bacteriologist if he is to get all the facts of the case.

In conclusion, I believe plague is a permanent problem with us on the Pacific Coast and I fear that it is a problem that will extend as time goes on to other States. Especially to be feared is the pneumonic form of the disease which I am convinced is related to plague in the Arctomyinae. The consequences following the travel of an infected individual in the incubation stage from an endemic focus to regions climatically more favorable for the development of pneumonia are terrible to contemplate.

Science is never satisfied with its results, and it is ever striving to discover missing data and to elaborate and improve on the known.

MORBIDITY

Complete Reports for Following Diseases for Week Ending April 24, 1937

Chickenpox

1104 cases: Alameda County 6, Alameda 33, Albany 1, Berkeley 43, Emeryville 3, Oakland 27, San Leandro 3, Butte County 2, Chico 7, Colusa 3, Contra Costa County 15, Pittsburg 1, Fresno County 27, Fresno 23, Eureka 7, El Centro 6, Kern County 10, Bakersfield 1, Kings County 3, Los Angeles County 50, Alhambra 3, Beverly Hills 7, Burbank 12, Covina 1, Culver City 5, Glendale 7, Hermosa 7, Huntington Park 11, Inglewood 1, Long Beach 50, Los Angeles 144, Pasadena 20, Pomona 11, Redondo Beach 1, San Fernando 1, Santa Monica 7, Sierra Madre 2, South Pasadena 1, Whittier 2, Torrance 1, South Gate 3, Maywood 3, Bell 3, Madera County 1, Monterey County 4, Salinas 13, Soledad 2, Napa County 9, Napa 23, Grass Valley 1, Orange County 17, Anaheim 5, Fullerton 14, Newport Beach 1, Orange 1, Santa Ana 4, Tustin 1, Riverside County 9, Corona 4, Riverside 5, Sacramento 32, San Bernardino 2, San Diego County 12, La Mesa 28, National City 10, San Diego 41, San Francisco 142, San Joaquin County 2, Stockton 9, Tracy 4, San Luis Obispo County 3, San Luis Obispo 9, Daly City 6, Santa Barbara County 22, Santa Barbara 6, Santa Clara County 26, Gilroy 2, Palo Alto 17, San Jose 7, Sunnyvale 8, Stanislaus County 2, Modesto 2, Tulare County 8, Lindsay 2, Tuolumne County 2, Sonora 1, Ventura County 1, Yolo County 7, Davis 3.

Diphtheria

53 cases: Oakland 2, Fresno County 1, Kern County 3, Bakersfield 1, Kings County 2, Hanford 2, Los Angeles County 2, Alhambra 1, Beverly Hills 4, Long Beach 1, Los Angeles 15, Riverside County 1, Sacramento 1, San Bernardino County 2, San Diego County 1, San Diego 2, San Francisco 1, San Joaquin County 2, Stockton 1, Santa Barbara 1, Sutter County 6, Marysville 1.

German Measles

51 cases: Albany 1, Berkeley 5, Oakland 3, Pittsburg 1, Fresno County 1, Eureka 2, Los Angeles County 9, Inglewood 1, Long Beach 2, Los Angeles 5, Pomona 1, San Gabriel 1, Orange County 1, Anaheim 2, Riverside County 1, San Diego County 1, San Francisco 7, San Joaquin County 1, Manteca 1, Santa Clara County 1, Santa Cruz 1, Turlock 1, Lindsay 1, Yolo County 1.

Influenza

209 cases: Oakland 1, Fresno County 4, Kern County 4, Kings County 168, Los Angeles County 5, Los Angeles 9, Whittier 1, Madera County 1, Brea 3, Colfax 2, Riverside 1, San Diego County 1, San Francisco 7, Stanislaus County 1, Oakdale 1.

Malaria

One case: Marysville.

Measles

309 cases: Alameda 2, Berkeley 1, Oakland 3, Chico 1, Imperial County 4, El Centro 8, Kern County 5, Los Angeles County 4, Glendale 10, Glendora 1, Huntington Park 1, Long Beach 23, Los Angeles 17, Pasadena 1, San Fernando 1, South Gate 1, Yosemite National Park 2, Anaheim 7, Fullerton 1, Huntington Beach 1, Placer County 36, Auburn 81, Colfax 2, Riverside County 3, Corona 2, Sacramento County 29, Sacramento 25, San Diego County 3, National City 1, San Diego 2, San Francisco 7, San Joaquin County 5, San Luis Obispo County 3, San Jose 1, Sutter County 1, Tulare County 2, Lindsay 1, Yuba County 4, Marysville 7.

Mumps

778 cases Alameda County 3, Alameda 19, Albany 2, Berkeley 45, Oakland 13, Chico 1, Contra Costa County 10, Martinez 3, Pittsburg 5, Fresno County 14, Fresno 2, Willows 1, Humboldt County 1, Eureka 8, El Centro 4, Imperial 2, Kern County 9, Kings County 18, Hanford 10, Los Angeles County 56, Alhambra 5, Arcadia 1, Beverly Hills 1, El Monte 1, Glendale 3, Hermosa 2, Huntington Park 4, Long Beach 9, Los Angeles 47, Manhattan 2, Pasadena 13, Pomona 1, Redondo 6, Santa Monica 6, Whittier 1, Lynwood 1, Hawthorne 1, South Gate 2, Madera County 2, Madera 3, San Rafael 1, Monterey County 13, King City 2, Napa County 1, Napa 5, Orange County 22, Anaheim 1, Brea 1, Fullerton 10, Orange 9, Santa Ana 21, La Habra 2, Riverside County 5, Beaumont 2, Hemet 12, Riverside 17, Sacramento County 2, Sacramento 7, Colton 1, Ontario 2, Redlands 1, San Bernardino 1, San Diego County 15, Chula Vista 6, La Mesa 3, National City 1, San Diego 66, San Francisco 132, San Joaquin County 1, Stockton 6, San Luis Obispo County 2, Paso Robles 1, Burlingame 1, Daly City 2, Hillsborough 1, Santa Barbara County 5, Lompoc 1, Santa Barbara 2, Santa Clara County 7, Palo Alto 4, San Jose 6, Shasta County 2, Solano County 1, Turlock 3, Tulare County 12, Lindsay 2, Ventura County 16, Santa Paula 4, Davis 1.

Pneumonia (Lobar)

62 cases: Albany 1, Oakland 1, Butte County 1, Kern County 1, Los Angeles County 6, Azusa 3, Glendale 1, Los Angeles 32, San Fernando 1, Monterey Park 1, San Rafael 1, Merced County 1, Anaheim 1, Riverside County 1, Riverside 1, Sacramento 2, San Bernardino 1, San Diego County 1, San Francisco 3, San Jose 1, Watsonville 1.

Scarlet Fever

225 cases: Alameda County 1, Alameda 1, Albany 1, Berkeley 2, Oakland 4, Butte County 1, Chico 5, Contra Costa County 3, Martinez 4, Fresno County 8, Fresno 4, Kingsburg 2, Humboldt County 2, Eureka 2, Fortuna 1, Kern County 11, Bakersfield 2, Kings County 5, Corcoran 1, Los Angeles County 20, Alhambra 5, Burbank 1, Compton 2, Culver City 2, Glendale 1, Inglewood 1, La Verne 1, Long Beach 1, Los Angeles 33, Manhattan 1, Pasadena 2, Pomona 2, Lynwood 1, Bell 3, Gardena 1, Madera County 1, Merced County 3, Carmel 1, Napa County 2, Napa 1, Orange County 2, Brea 1, Santa Ana 1, Auburn 2, Colfax 4, Riverside County 4, Sacramento 2, Ontario 2, Redlands 2, San Bernardino 2, San Diego County 3, National City 1, San Diego 7, San Francisco 11, San Joaquin County 3, Stockton 2, Tracy 1, San Luis Obispo County 1, Paso Robles 2, Daly City 1, Santa Barbara County 2, Santa Barbara 2, Santa Clara County 1, Palo Alto 1, San Jose 7, Santa Cruz 1, Redding 2, Etna 1, Tulare County 8, Lindsay 2, Ventura County 1.

Smallpox

21 cases: Berkeley 1, Oakland 1, Kern County 1, Los Angeles County 2, Glendale 1, Los Angeles 5, Monterey County 1, Beaumont 2, Riverside 2, San Bernardino 1, San Diego 2 , Siskiyou County 2.

Typhoid Fever

8 cases: El Monte 1, San Diego 2, San Francisco 1, San Joaquin County 1, Tulare County 1, California 2.*

Whooping Cough

802 cases: Alameda County 2, Alameda 3, Albany 6, Berkeley 6, Oakland 8, San Leandro 2, Butte County 6, Chico 2, Colusa 2, Contra Costa County 7, Fresno County 21, Fresno 22, Willows 9, Imperial County 8, Calexico 1, Kern County 3, Bakersfield 2, Kings County 14, Hanford 7, Lake County 1, Los Angeles County 67, Alhambra 4, Arcadia 4, Azusa 4, Burbank 5, Claremont 22, Compton 1, Culver City 2, El Monte 6, Glendale 2, Glendora 1, Hermosa 1, Long Beach 7, Los Angeles 105, Manhattan 4, Monrovia 6, Pasadena 33, Pomona 9, Redondo 1, San Fernando 11, South Pasadena 5, Whittier 4, South Gate 3, Monterey Park 7, Madera County 4, Merced County 1, Orange County 31, Anaheim 3, Fullerton 2, Newport Beach 10, Orange 7, Santa Ana 12, La Habra 12, Laguna Beach 2, Placer County 8, Auburn 3, Riverside County 7, Riverside 3, Sacramento 2, San Bernardino 4, La Mesa 7, San Diego 8, San Francisco 24, San Joaquin County 41, Lodi 9, Stockton 13, Tracy 2, San Luis Obispo County 7, Santa Barbara County 25, Santa Barbara 13, Santa Maria 11, Santa Clara County 7, San Jose 1, Santa Cruz 1, Shasta County 4, Stanislaus County 1, Turlock 1, Tulare County 39, Ventura County 10, Oxnard 2, Yolo County 3, Woodland 16.

Meningitis (Epidemic)

5 cases: Amador County 1, Los Angeles County 1, Los Angeles 2, Corona 1.

Dysentery (Amoebic)

3 cases: Los Angeles 1, San Francisco 2.

Dysentery (Bacillary)

5 cases: Los Angeles 2, Mariposa County 2, Tulare County 1.

Pellagra

3 cases: Madera 1, San Luis Obispo County 1, San Jose 1.

Poliomyelitis

2 cases: Los Angeles 1, Santa Ana 1.

Tetanus

2 cases: Los Angeles.

Trachoma

2 cases: Fresno County 1, Kings County 1.

Encephalitis (Epidemic)

One case: San Diego.

Hookworm

One case: Fillmore.

Paratyphoid Fever

One case: Imperial County.

Jaundice (Epidemic)

3 cases: Humboldt County.

Food Poisoning

11 cases: Los Angeles 6, Santa Ana 1, San Francisco 4.

Undulant Fever

8 cases: Kern County 1, Alhambra 1, Long Beach 1, Pasadena 1, Whittier 1, Santa Ana 1, Riverside 1, San Bernardino 1.

Coccidioidal Granuloma

2 cases: Kern County 1, San Bernardino County 1.

Septic Sore Throat (Epidemic)

5 cases: Santa Monica 1, Ontario 3, Daly City 1.

Rabies (Animal)

49 cases: Hanford 1, Los Angeles County 9, Glendale 2, Hermosa 1, Long Beach 2, Los Angeles 24, Manhattan 1, Whittier 1, Torrance 1, South Gate 1, Monterey Park 1, Gardena 1, Monterey County 3, Sacramento 1.

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* Cases charged to "California" represent patients ill before entering the State or those who contracted their illness traveling about the State throughout the incubation period of the disease. These cases are not chargeable to any one locality.

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